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(Rev. 9-2001)

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

ATTORNEY'S DOCKET NUMBER

**TRANSMITTAL LETTER TO THE UNITED STATES
DESIGNATED/ELECTED OFFICE (DO/EO/US)
CONCERNING A FILING UNDER 35 U.S.C. 371**

004501-631

U.S. APPLICATION NO. (If known, see 37 C.F.R. 1.5)

Unassigned

10/009800

INTERNATIONAL APPLICATION NO.
PCT/CH00/00325INTERNATIONAL FILING DATE
June 14, 2000PRIORITY DATE CLAIMED
June 17, 1999

TITLE OF INVENTION

ELECTRIC CIRCUIT BREAKER FOR PROTECTING AGAINST OVERCURRENTS

APPLICANT(S) FOR DO/EO/US

Ralf STRÜMLER

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. ☒ The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
 - a. ☐ is attached hereto (required only if not communicated by the International Bureau).
 - b. ☒ has been communicated by the International Bureau.
 - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
- ☒ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2))
 - a. ☒ is attached hereto.
 - b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
- ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
 - a. ☐ are attached hereto (required only if not communicated by the International Bureau).
 - b. ☐ have been communicated by the International Bureau.
 - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
 - d. ☒ have not been made and will not be made.
- ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☒ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A **FIRST** preliminary amendment.
14. ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
15. ☐ A substitute specification.
16. ☐ A change of power of attorney and/or address letter.
17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
18. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. ☒ Other items or information: Formal Drawings, Figures 1-7 (6 pages); Amended Sheets in the German language (6 pages) and English language translation of the amended sheets (8 pages); published application WO 00/79664 A1; PCT Forms - IPEA/416, IPEA/409, IB/332, IB/304, IB/301, RO/105, and RO/101



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|--|--------------|---|--|--|--------------|
| U.S. APPLICATION NO. (if known) 10/009800 | | INTERNATIONAL APPLICATION NO. PCT/CH00/00325 | | ATTORNEY'S DOCKET NUMBER 004501-631 | |
| 21. <input checked="" type="checkbox"/> The following fees are submitted: | | | | CALCULATIONS | PTO USE ONLY |
| Basic National Fee (37 CFR 1.492(a)(1)-(5)): Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO \$1,040.00 (960) International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO \$890.00 (970) International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO \$740.00 (958) International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) \$710.00 (956) International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) \$100.00 (962) | | | | | |
| ENTER APPROPRIATE BASIC FEE AMOUNT = \$ 890.00 | | | | | |
| Surcharge of \$130.00 (154) for furnishing the oath or declaration later than months from the earliest claimed priority date (37 CFR 1.492(e)). 20 <input type="checkbox"/> 30 <input type="checkbox"/> | | | | | |
| Claims | Number Filed | Number Extra | Rate | | |
| Total Claims | 18 -20 = | -0- | X\$18.00 (966) | \$ -0- | |
| Independent Claims | 1 -3 = | -0- | X\$84.00 (964) | \$ -0- | |
| Multiple dependent claim(s) (if applicable) | | | + \$280.00 (968) | \$ -0- | |
| TOTAL OF ABOVE CALCULATIONS = | | | | \$ 890.00 | |
| Reduction for 1/2 for filing by small entity, if applicable (see below). | | | | + \$ -0- | |
| SUBTOTAL = | | | | \$ 890.00 | |
| Processing fee of \$130.00 (156) for furnishing the English translation later than months from the earliest claimed priority date (37 CFR 1.492(f)). 20 <input type="checkbox"/> 30 <input type="checkbox"/> | | | | \$ -0- | |
| TOTAL NATIONAL FEE = | | | | \$ 890.00 | |
| Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). \$40.00 (581) per property | | | | + \$ 40.00 | |
| TOTAL FEES ENCLOSED = | | | | \$ 930.00 | |
| | | | | Amount to be refunded: | \$ |
| | | | | charged: | \$ |
| a. <input type="checkbox"/> Small entity status is hereby claimed. b. <input checked="" type="checkbox"/> A check in the amount of \$ <u>930.00</u> to cover the above fees is enclosed. c. <input type="checkbox"/> Please charge my Deposit Account No. <u>02-4800</u> in the amount of \$ _____ to cover the above fees. A duplicate copy of this sheet is enclosed. d. <input checked="" type="checkbox"/> The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. <u>02-4800</u> . A duplicate copy of this sheet is enclosed. | | | | | |
| NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status. | | | | | |
| SEND ALL CORRESPONDENCE TO: BURNS, DOANE, SWECKER & MATHIS, L.L.P. P.O. Box 1404 Alexandria, Virginia 22313-1404 (703) 836-6620 | | | | | |
| | | | SIGNATURE Robert S. Swecker NAME | | |
| | | | 19,885 REGISTRATION NUMBER | | |
| | | | December 13, 2001 DATE | | |

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531 Rec'd PCT/CH 13 DEC 2001

Patent

Attorney's Docket No. 004501-631

#3/a

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of)
Ralf STRÜMLER) Group Art Unit: Unassigned
Application No.: Unassigned) Examiner: Unassigned
Corresponding to PCT/CH00/00325)
Filed: December 13, 2001)
For: ELECTRIC CIRCUIT BREAKER)
FOR PROTECTING AGAINST)
OVERCURRENTS)

PRELIMINARY AMENDMENT

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

Prior to examination of the above-captioned patent application, kindly enter the following amendment.

IN THE CLAIMS:

Please replace claims 3-6 and 9-18 of the amended sheets as follows.

--3. (Amended) The electrical switching device as claimed in claim 1, wherein the short-circuit current limiter is a fuse link.

4. (Amended) The switching device as claimed in claim 1, wherein the short-circuit current limit can be uploaded electrically, and the evaluation device is designed to

transmit a second tripping signal to the short-circuit current limiter in the event of large overcurrents.

5. (Amended) The electrical switching device as claimed in claim 1, wherein the short-circuit current limiter is a power breaker.

6. (Amended) The electrical switching device as claimed in claim 1, wherein the short-circuit current limiter is a PTC thermistor.

9. (Amended) The electrical switching device as claimed claim in 1, wherein the evaluation device is designed for receiving and evaluating signals from a first current sensor, which detects the current through the current path, and from a second current sensor, which detects a current through a second current path, by comparing them with one another and opening the microrelay switch in response to a result of the evaluation.

10. (Amended) The electrical switching device as claimed in claim 1, wherein the current sensor is a total current sensor which detects a total current through the current path and through at least one second adjacent current path, and the evaluation device is designed for receiving and evaluating a signal from the total current sensor and for opening the microrelay switch in response to that signal.

11. (Amended) The electrical switching device as claimed in claim 1, wherein at least one current sensor is part of the switching device and is in the form of a Hall sensor.

12. (Amended) The electrical switching device as claimed in claim 1, wherein the microrelay switch, the evaluation device and, possibly, the Hall sensor or sensors are each integrated as chips on a circuit board.

13. (Amended) The electrical switching device as claimed in claim 1, wherein the microrelay switch and the evaluation device are integrated on one chip.

14. (Amended) The electrical switching device as claimed in claim 11, wherein the evaluation device and the Hall sensor or sensors are integrated on a chip.

15. (Amended) The electrical switching device as claimed in claim 11, wherein the microrelay switch, the evaluation device and the Hall sensor or sensors are integrated on one chip.

16. (Amended) The electrical switching device as claimed in claim 1, wherein an electronic response monitoring device is integrated, with the microrelay switch, on one chip.

17. (Amended) The electrical switching device as claimed in claim 1, wherein a timer circuit is integrated, with the microrelay switch, on one chip.

18. (Amended) An electric motor switching and protection system having an electrical switching device as claimed in claim 1.--

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REMARKS

Entry of the foregoing and prompt and favorable consideration of the application are respectfully requested.

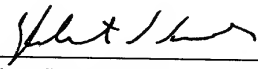
The claims have been amended to eliminate multiple dependency and delete the reference numerals and to place them in better condition for U.S. patent practice. These amendments are not intended, nor should they be construed, to narrow the scope of any of the amended claims.

In the event that there are any questions relating to the Preliminary Amendment, or the application in general, it would be appreciated if the Examiner would telephone the undersigned attorney concerning such questions so that prosecution of this application may be expedited.

Respectfully submitted,

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By: _____


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Date: December 13, 2001

Application No. Unassigned
Attorney's Docket No. 004501-631
Mark-up of Claims - Page 1 of 3

Attachment to Amendment dated December 13, 2001

--3. (Amended) The electrical switching device as claimed in claim 1 [or 2], [in which] wherein the short-circuit current limiter is a fuse link [(11)].

4. (Amended) The switching device as claimed in claim 1 [or 2], [in which] wherein the short-circuit current limit [(17)] can be uploaded electrically, and the evaluation device [(7)] is designed to transmit a second tripping signal [(18)] to the short-circuit current limiter [(17)] in the event of large overcurrents.

5. (Amended) The electrical switching device as claimed in claim 1, [2 or 3, in which] wherein, the short-circuit current limiter is a power breaker [(17)].

6. (Amended) The electrical switching device as claimed in claim 1, [one of the preceding claims, in which] wherein the short-circuit current limiter is a PTC thermistor [(16)].

9. (Amended) The electrical switching device as claimed in claim 1, [one of the preceding claims, in which] wherein the evaluation device [(7)] is designed for receiving and evaluating signals from a first current sensor [(5)], which detects the current through the current path [(8)], and from a second current sensor, which detects a current through a

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second current path, by comparing them with one another and opening the microrelay switch [(1)] in response to a result of the evaluation.

10. (Amended) The electrical switching device as claimed in claim 1, [one of claims 1-8, in which] wherein the current sensor [(5)] is a total current sensor which detects a total current through the current path [(8)] and through at least one second adjacent current path, and the evaluation device [(7)] is designed for receiving and evaluating a signal from the total current sensor and for opening the microrelay switch [(1)] in response to that signal.

11. (Amended) The electrical switching device as claimed in claim 1, [one of the preceding claims, in which] wherein at least one current sensor [(5)] is part of the switching device and is in the form of a Hall sensor.

12. (Amended) The electrical switching device as claimed in claim 1, [one of the preceding claims, in which] wherein the microrelay switch, the evaluation device and, possibly, the Hall sensor or sensors are each integrated as chips on a circuit board.

13. (Amended) The electrical switching device as claimed in claim 1, [one of the preceding claims, in which] wherein the microrelay switch [(1)] and the evaluation device [(7)] are integrated on one chip [(6)].

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14. (Amended) The electrical switching device as claimed in claim 11, [also in conjunction with any further one of the preceding claims, in which] wherein the evaluation device [(7)] and the Hall sensor or sensors [(5)] are integrated on a chip [(6)].

15. (Amended) The electrical switching device as claimed in claim 11, [also in conjunction with any further one of the preceding claims, in which] wherein the microrelay switch [(1)], the evaluation device [(7)] and the Hall sensor or sensors [(5)] are integrated on one chip [(6)].

16. (Amended) The electrical switching device as claimed in claim 1, [one of the preceding claims, in which] wherein an electronic response monitoring device [(7)] is integrated, with the microrelay switch [(1)], on one chip [(6)].--

17. (Amended) The electrical switching device as claimed in claim 1, [one of the preceding claims, in which] wherein a timer circuit is integrated, with the microrelay switch [(1)], on one chip [(6)].

18. (Amended) An electric motor switching and protection system having an electrical switching device as claimed in claim 1 [one of the preceding claims].

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531 Rec'd PCT/PTC 13 DEC 2001

Electrical switching device for overcurrent protection

The invention relates to an electrical switching device for switching off an overcurrent in a current path. In particular, the invention in this case relates to the field of domestic electrical power supply, to the field of relatively small and medium-size electric motors, to building technology, to lighting systems and to electrical systems in railroad vehicles, ships and the like. These fields of application can be characterized by the fact that the voltages to be switched off are typically 100 V - 1 kV, and the typical load currents are in the range 0.1 A - 75 A, although these numerical figures should not be regarded as representing any restriction. In particular, very large current values can occur briefly in the event of large overcurrents caused by a short circuit or the like.

The invention relates to a switching device which can switch off not only relatively small overcurrents, which are in the range 1.1 to 10 times the maximum permissible current, but also very large overcurrents of many times the maximum permissible current, in order to protect an electrical device against damage or to be prevent damage to the environment or to personnel.

In the prior art, combinations of electromagnetic contactors, fuse links, thermal overload relays with a bimetallic strip as the tripping element, and the like have been used until now.

On the other hand, electrical systems and devices have been becoming ever more complex in recent times, particularly in the low-voltage field, while, on the other hand, there has been an increasing requirement to reduce the total price, the physical volume, the weight and also the power losses.

The invention is based on the technical problem of finding an improved electrical switching device for switching off overcurrents.

- 5 The invention solves this problem by means of an electrical switching device having a microrelay switch in a current path, having a short-circuit current limiter in the current path for interrupting a large overcurrent, and having an evaluation device for
- 10 receiving and evaluating signals from a current sensor which detects the current through the current path, with the switching device being designed such that the microrelay switch opens in response to a tripping signal from the evaluation device in the event of small
- 15 overcurrents above a threshold value and, in the event of large overcurrents, the short-circuit current limiter limits these currents to currents which can be interrupted by the microrelay switch.
- 20 The invention is furthermore also based on an electric motor switching and protection system having such an improved switching device.

- The fundamental idea of the invention is thus to use a
- 25 microrelay switch in conjunction with a further component for short-circuit current limiting, instead of the conventional electromagnetic contactor. In this case, the microrelay switch is intended to be designed to switch off small overcurrents, and, furthermore, can
- 30 also be used for the normal switching on and off of the current in the current path during normal operation. In contrast to this, a further apparatus for short-circuit current limiting is designed specifically for switching off very large overcurrents, which would destroy the
- 35 microrelay switch. An evaluation device is used for detecting overcurrents and for tripping the microrelay switch but, when required, can also be actuated directly for switching on and off. The invention thus makes it possible to save the conventional components

comprising thermal relays with bimetallic strips and electromagnetic contactors, and/or to replace them by a comparatively small and light electromechanical system.

- 5 The microrelay switch as such is prior art and is an electrically operated miniature switch. In contrast to a transistor, a microrelay is, however, a mechanical switch with at least one moving contact piece.
- 10 This contact piece can be caused to move mechanically by means of an electrical signal in various ways. In general, such microrelay switches are produced using known methods for microelectronics and microsystem engineering.
- 15 The devices for the invention are preferably electrostatically operated microrelay cells, that is to say those in which the moving contact piece is operated electrostatically. In this context, reference is made
- 20 to the exemplary embodiments and to an Si microrelay published by Siemens (H.F. Schlaak, F. Arndt, J. Schimkat, M. Hanke, Proc. Micro System Technology 96, 1996, pages 463-468). Reference is also made to R. Allen: "Simplified Process is Used to Make
- 25 Micromachined FET-like Four-Terminal Microswitches and Microrelays" in Electronic Design, 8 July, 1996, page 31, and to "Micromechanic Membrane Switches on Silicon" in K.E. Petersen, IBM J. RES. DEVELOP., Volume 23, No. 4, July 1979, pages 376-385.
- 30 The expression microrelay switch, for the purposes of this invention, relate to a switching device which has at least one microrelay cell. As described in detail further below, the microrelay switch may, however, be a
- 35 complex system comprising a number of individual microrelay cells, with each individual cell having (at least) one moving contact piece.

In comparison to the described conventional component combinations, the switching device according to the invention thus offers a considerable reduction in weight and physical volume. The geometric flexibility

5 of the overall arrangement is also improved, since the microrelay switch can be installed in widely differing manners, is at the same time particularly robust and insensitive to temperature fluctuations, shocks or the like and, in the case of a relatively large arrangement
10 having a large number of microrelay cells, also provides major design freedom, since the conductor tracks between the microrelay cells can be formed as required.

15 A further primary advantage of the novel electrical switching device is the very rapid response of the microrelay switch. Due to the very much lower inertia of the moving masses, this represents a fundamental advantage in comparison to solutions using conventional
20 contactors and relays. This is still true without any restriction even in the case of relatively complex microrelay switches having a greater number of microrelay cells, since the response time in this case is essentially the same as that with a single cell.

25 Furthermore, typical switching ratings and the power consumption of microrelay switches in the quiescent state are considerably reduced in comparison to conventional relays and contactors, and thus contribute
30 to power saving and to reducing thermal problems, in particular in relatively large systems. Furthermore, the switching device according to the invention can also be used in combination with and for integration with other semiconductor-technology devices, in
35 particular transistors and integrated circuits, since there are considerable corresponding features and overlapping areas in the production methods. The weight, volume and cost can thus be reduced further.

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interrupts a large overcurrent by the melting of an incandescent filament or of a conductor track, but does not operate repetitively, that is to say it must be replaced. Such a fuse link is blown by the overcurrent itself, and thus does not require any actuation by the evaluation device.

A further option, however, is electrically operable tripping of the short-circuit current limiter. In this case, it is possible, but not essential, for the actuation of the short-circuit current limiter to use a further actuation signal (referred to as a second actuation signal in the following text) from the same evaluation device which also actuates the microrelay switch. By way of an example, an electrically tripped power breaker can be used for this purpose. However, it is also possible to use an entirely conventional power breaker, for example with an electromagnetic drive supplied by a short-circuit current.

A further version of the invention is for a PTC thermistor to be used as a short-circuit current limiter, or in addition to another switch, in a short-circuit current limiter. Such a PTC thermistor is defined by its electrical resistance having a positive temperature coefficient, which is sufficient that the heating of the thermistor at very large overcurrents causes a sufficiently severe rise in the resistance value to limit the overcurrent to values which can be switched off by the microrelay switch. This is the explanation of the term short-circuit current limiter, which thus covers both components which completely interrupt the short-circuit current and components which limit it to values which can be switched off by the microrelay switch.

Preferable PTC materials include PTC polymers, which generally consist of a polymer matrix with a filling material which is distributed in it and promotes

electrical conductivity. The filling material may be, for example, metal particles, carbides, borides, nitrides, short carbon fibers, conductive polymer particles or else carbon black. Limiting can in this

- 5 case can be carried out by means of a resistance rise by a factor of at least 2.5 in a temperature interval of 14 K, a factor of 6 in a temperature interval of 30 K, or a factor 10 in a temperature interval of 100 K, satisfying a criterion for definition.
- 10 Preferable factors in this case are 5, 20 and 100, or 7.5, 100 and 1000, in the respective temperature intervals.

According to a further version of the invention, the

15 switching device furthermore contains a fault current protection function. For this purpose, the current through two current paths is either detected or compared by means of two current sensors, with the result of this evaluation being used appropriately to

20 open at least one microrelay switch in one of the two current paths, or a current sensor which is referred to here as a total current sensor can also be used to detect and evaluate a total current through two adjacent current paths, in order to open the microrelay

25 switch. This is intended to mean a current sensor which, on the basis of the spatial conditions, detects the total (calculated for fault current detection) of both currents, taking into account their directions. For example, two conductor tracks as the current paths

30 may carry the currents to be compared in mutually opposite directions, with the total current sensor detecting the total current, that is to say a zero current if the magnitudes of the currents are the same. Accordingly, the signal from the total current sensor

35 may be compared only with a correspondingly small threshold value by the evaluation device, in order to actuate the microrelay switch.

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The current sensors mentioned several times in this description need not necessarily be part of the switching device according to the invention. In the simplest case, they may be conventional current sensors, for example induction coils. However, the invention preferably relates to Hall sensors, which can be produced with very small verification limits, for example with verification limits of about 1 mA in comparison to conventional verification limits of approximately 10 mA or more. Hall sensors can furthermore be produced as semiconductor elements to be very much smaller, lighter and also cheaper than conventional induction coils.

On the basis of what has been said above, the term microrelay switch may mean both an individual microrelay and a circuit comprising a relatively large number of microrelay cells. This should be understood in particular as meaning that, in any case in the present-day development standard, microrelays do not have an unrestricted current-carrying capacity and withstand voltage, and have only limited capabilities to switch off relatively high power levels. When the particular applications require load capacities beyond the given limits of an individual microrelay cell, it is possible to use, according to the invention, voltage-dividing series circuits comprising two or more microrelay cells, and/or current-dividing parallel circuits. When combined, these are switch panels, namely voltage-dividing series circuits or parallel circuits which have a current-dividing effect in each stage of the series circuit.

However, in this context, it must be remembered that the technological limits in the present-day situation are subject to continual changes. Further improvements can be predicted with respect to the voltage and load capacities when switched on, and also with respect to the disconnection capacity. A joint research project between the manufacturer Bosch and a group at Bremen University is working on the development of microrelays with a maximum switching voltage of 24 V, and a maximum switching current of 25 A. It can thus be assumed that, in future, it will be possible to satisfy even applications with somewhat more stringent requirements just by individual microrelays. This relates in particular to the current-carrying capacity, and it should then be possible to achieve the required withstand voltage by appropriate series connection.

Reference should now be made once again to an already mentioned advantage of the technologies that are typical for microrelays. For matching to a specific electrical configuration, a standardized microrelay cell based on a fixed standard technology can be designed for different parameter magnitudes by parallel and/or series connection. This can be done just by changing the layout geometry, for example by using a different mask set. The rest of the production process can remain virtually unchanged. This exploits the likewise already mentioned advantage of the very high response speed without scaling directly into the overall circuit. It is thus possible to produce extremely fast-response switching devices, in particular, with stringent specification values, in comparison to equivalent conventional contactors.

In addition to the integration of a switch panel having a number of microrelay cells, other integration versions are also of importance to the invention. The microrelay switch or switches, the evaluation device and, possibly, also the Hall sensor or sensors can, on

the one hand, each be in the form of semiconductor chips and can be mounted on a common circuit board. This itself results in considerable advantages since the mounting technologies are identical or similar, and
5 the combined components have a small physical size and low weight. As an example of a form of a Hall sensor which is highly related to microelectronics, reference is made here to the "Cylindrical Hall Device" by H. Blanchard, L. Chiesi, R. Racz and R.S. Popovic,
10 Proceedings IEDM 96, pages 541-544, IEEE 1996.

When combined with a Hall sensor, it may, on the other hand, be advantageous to dispense with complete integration, since it then possible to design a more
15 highly standardized switching device using Hall sensors of different design depending on the application, for respective response values.

It is, of course, also possible for different
20 components to be combined with one another on one chip. For example, the evaluation device and the microrelay switch or switches may be integrated. With suitable technology, this also relates to the Hall sensor or sensors. If, on the other hand, only the evaluation
25 device and the Hall sensor or sensors are integrated, while the microrelay switch or switches is or are in the form of a separate chip or chips, this allows the combination of a standardized chip with an evaluation device and a Hall sensor or Hall sensors with
30 different, electrically differently designed, microrelay switches. Furthermore, temperature sensors, timer circuits and other electronic devices can also be combined and integrated.

35 In addition, this also relates to an electronic response monitoring device, which can likewise be combined or integrated. Such a response monitoring device registers the response of the electrical switching device and may, for example, be used to

inhibit the switching device for a certain amount of time after it has tripped. Furthermore, a defined test can be carried out after tripping, for example by means of a short switched-on state, in which a check is carried out to determine whether the fault state that was responsible for the previous tripping is still present. Automatic reconnection is thus possible, for example, following a temporary current surge. Interfaces to external control devices can also be provided.

In addition, timer circuits can also be combined or integrated, for example allowing use as an automatic time switch for lighting applications, for example stairwells.

Finally, of course, devices for indicating the response to an overcurrent or a fault current in a visual or audible form are also possible.

One preferred application of the invention is a switching and protection system for an electric motor. The exemplary embodiments which are described in detail in the following text also relate to this, in which case, disclosed features may also be significant to the invention in other combinations. In the figures:

Figure 1 shows a conventional electric motor switching and protection system;

Figure 2 shows an electric motor switching and protection system according to the invention, having a switching device according to the invention, as a first exemplary embodiment;

Figure 3 shows an illustration of a detail from Figure 2, with details of the microrelay switch;

Figure 4 shows an alternative to Figure 2, as a second exemplary embodiment;

5 Figure 5 shows a further alternative to Figures 2 and 4, as a third exemplary embodiment;

Figure 6 shows a timing diagram to explain the second exemplary embodiment from Figure 4; and

10 Figure 7 shows a further timing diagram to explain the third exemplary embodiment from Figure 5.

First of all, Figure 1 shows the prior art. In this case, a device for switching and for protection of an electric motor 14 in a current path 8, which supplies the electric motor 14, has a fuse link 11 for protection against very large overcurrents, and a combination of a thermal relay 12 and an electromagnetic contactor 13 for protection against small overcurrents. The thermal relay 12 detects small overcurrents by the heating of a bimetallic strip, with the opening bimetallic strip interrupting the current supply to the electromagnetic contactor 13, in response to which this opens and hence interrupts the power supply to the electric motor 14. A switch 15 in the supply to the electromagnetic contactor 13 is used for switching the electric motor 14 on and off during normal operation.

30 In contrast, Figure 2 shows an arrangement according to the invention, in which the thermal relay 12 and the electromagnetic contactor 13 have been replaced by a microrelay switch 1 with a Hall sensor 5, integrated on the same chip 6, as the current sensor, and an evaluation device 7, which actuates the microrelay switch 1 via a tripping signal 9. The rest of the elements correspond to the conventional example in Figure 1.

The construction of the microrelay switch 1 will be explained in detail first of all. In this context, Figure 3 shows the microrelay switch 1 formed from 17 series-connected stages 2, each having 45 parallel-connected microrelay cells 3. Each microrelay cell 3 corresponds technologically to the already mentioned Siemens silicon microrelay, and is electrically connected to in each case one microrelay cell 3 in the previous stage 2, and one in the subsequent stage 2. For the first and last of the stages 2, the connections are in each case joined together on the respective outer side, and are connected to a common connection of the microrelay switch 1.

In a highly schematic illustration, it is also possible to see a moving contact piece 4 which, in this case, corresponds to a bar which can be bent or deflected electrostatically. The essential feature of the switching device according to the invention is that all these movable contact pieces 4 operate in synchronism, that is to say they are opened and closed by a single common signal, to the extent that parts act on a jointly constructed, standard switch.

Each individual microrelay cell 3 can interrupt a voltage of about 24 V, so that the microrelay switch 1 can switch off a voltage of 400 V. This value is advantageous for many applications and, in particular, values above 200 or 300 V are preferable.

The load current which can be switched by each microrelay cell 3 is about 200 mA, thus resulting in a total current of about 9 A for the microrelay switch 1.

These values are chosen such that they can be compared directly with a conventional standard contactor (for example A9 contactor (ABB Control, France)). This electromagnetic standard relay, with a disconnectable voltage of 400 V and a 9 A switchable load current,

consumes an activation power of 2 W. In contrast, the entire microrelay switch 1 of the switching device according to the invention has an activation power of only 5 mW, which is reduced by a factor of more than 500. With present-day technology, the power losses when switched on are somewhat lower (0.1 W) with conventional relays than for the microrelay switch 1 according to the invention, of 0.6-6 W. However, it will be possible to reduce this value considerably by further improvement of the contacts, and possibly by increasing the closing force of the microrelays. Freedom is evident for the closing force, particularly with regard to the extremely low activation power.

When comparing these values it must be remembered that conventional contactors are switched off when no power is flowing, that is to say they consume said activation power when in the connected state. Thus, for example, the A9 contactor consumes about 2.1 W when switched on, which is thus a multiple of the value which can be achieved by the invention.

Figure 2 shows the Si chip 6 corresponding to the switching device according to the invention and with the microrelay switch 1 which has already been described with reference to Figure 3. In addition, the Hall sensor 5 is provided underneath the outermost (lowermost in the figure) stage 2 of the microrelay switch 1. This is a Hall sensor integrated on the Si chip 6, and is configured suitably for radial magnetic fields, such as those which occur in linear current conductors. In this context, reference is made to the already cited publication "Cylindrical Hall Device". The Hall sensor 5 requires an actuation power of about 60-360 mW.

This Hall sensor 5 is controlled via a connecting line by the evaluation device 7, which evaluates the output signal from the Hall sensor 5, and applies the

appropriate current to the Hall sensor 5. To be precise, the evaluation device 7 compares the output signal from the Hall sensor 5 with a threshold value for definition of overcurrents. On detecting a current which is greater than an adjustable threshold value, the evaluation device 7 responds, and emits, via the line 9, a tripping signal to the microrelay switch 1, that it to say the microrelay switch 1 is switched between the switched-on and switched-off states. All the moving contact pieces 4 of the individual microrelay cells 3 are opened simultaneously and are closed simultaneously.

In this case, a time delay can be introduced, which prevents excessively fast response of the microrelay switch 1 before the short-circuit current limiter. This is because, if the microrelay switch 1 responds too quickly when the currents to be switched off are large, these large currents must be interrupted by the microrelay switch 1. It may therefore be advantageous to delay the opening process of the microrelay switch 1 until the short-circuit current limiter has carried out its function in the presence of this time delay, in any case when currents are dangerous to or could destroy the microrelay switch 1. In this case it must be remembered that the response of many short-circuit current limiters, for example fuse links or bimetallic tripping mechanisms in power breakers, become ever faster as the current to be switched off increases. Conversely, the response is slower when the currents to be switched off are smaller. To this extent, the time delay of the microrelay switch 1 can be chosen to be just sufficiently long that the short-circuit current limiter just interrupts for this time delay, for all currents which are dangerous to the microrelay switch 1.

The actuation of the microrelay switch 1 by means of an evaluation device 7 makes it possible, in particular,

to control the response of the microrelay switch 1 as a function of the magnitude of the measured current to be switched off, that is to say to allow the microrelay switch 1 to respond with a greater time delay to very large overcurrents. It is also possible, for example for use in an electric motor switch and protection system, for the response of the microrelay switch to take account of the motor starting current, which is typically greater by a factor (for example 6) than the rated current. This means that the evaluation device 7 uses a higher threshold value while the motor is being started than during continuous operation, so that the threshold value during the starting phase is somewhat greater than the motor starting current, and is somewhat greater than the motor rated current during the normal operating phase. In this context, reference is made to Figures 6 and 7 and the associated description in the following text.

In these exemplary embodiments, the evaluation device 7 is in the form of an integrated Si analogue circuit.

If required, it may also include a timer circuit 8, although this is not shown separately here.

Overall, the invention allows the function of a conventional contactor with actuation electronics and a current sensor to be implemented on the silicon chip 6. This results in a physical volume of the order of magnitude of $(30 \times 50 \times 1) \text{ mm}^3$, with a weight of about 10 g, as against comparable values for the already mentioned conventional electromagnetic A9 contactor of $(44 \times 74 \times 74) \text{ mm}^3$ and 340 g.

In the first exemplary embodiment, in Figure 2, a fuse link 11, as shown in Figure 1, is connected in series with the microrelay switch 1, in the current path 8. The fuse link 11 is used as a short-circuit current limiter and is not separately actuated. It blows

autonomously as a result of thermal overloading of a melting wire or of a conductor track and, accordingly, needs to be replaced. For this purpose, a switch is connected upstream of the fuse link 11, and a further switch is connected downstream from it, in order to allow the terminals of the fuse link 11 to be disconnected, for potential replacement. The switch between the fuse link 11 and the microrelay switch 11 is worthwhile because the microrelay switch 1 does not generally allow direct visual inspection to check that it is open and, after very high currents have been passed through, it is possible in some circumstances for the moveable contact pieces 4 to be welded. A conventional mechanical switch thus offers greater assurance that the corresponding terminal of the fuse link 11 is not live.

The current path 8 shown here may actually also correspond to a multiphase line. However, it is possible for another phase to continue without being interrupted to the electric motor 14, so that the switching device according to the invention interrupts only one of, for example, two supplying current paths. In general, this will be done in the phase line while, in contrast, the neutral conductor can be continued uninterrupted.

Figure 4 shows an alternative, second embodiment. In this case, the fuse link 11 is replaced by a PTC polymer thermistor 16 which, as a short-circuit current limiter, limits large overcurrents in the manner already described to very low currents, due to the electrical resistance value rising very sharply, in which case the microrelay switch 1 may also be used for DC isolation. The above statements and the explanatory notes relating to Figures 6 and 7 apply to the capability to control the time response of the microrelay switch 1. The PTC polymer thermistor 16 also has a response which is faster for large overcurrents.

The PTC polymer thermistor 16 is a repetitive element, and need not be replaced after it has responded. When the overcurrent is switched off, the PTC polymer thermistor 16 cools down to normal temperature, and thus returns to the original state. The major advantage of a PTC polymer thermistor in comparison to a PTC metal thermistor is that a PTC polymer thermistor has a sudden resistance rise, with the electrical resistance increasing by such considerable factors that it virtually disconnects the current path. However, a PTC polymer thermistor requires a certain cross-sectional area in order to be able to carry the appropriate load and in order not to have an excessive resistance during normal operation, as well.

Typical orders of magnitude could be, for example, a maximum disconnection current of 10 A for the microrelay switch 1 with a motor rated current of, for example 1 A, with the PTC polymer thermistor 16 responding at about 10 A. A PTC polymer thermistor 16 designed in accordance with the already cited application 198 33 609.8 dated July 25, 1998, would have a typical volume of about 4 cm x 2 mm (cross-sectional area) x 2 cm (including metal contacts).

The single line 18 shown in Figure 4 leads from the evaluation device 7 to a load-break switch 19 connected in series with the PTC polymer thermistor 16 and the microrelay switch 1. If the PTC polymer thermistor 16 has failed, or it has been impossible to prevent the moveable contact pieces 4 of the microrelay switch 1 from welding due to excessively late response, this load-break switch 19 can be used to disconnect the current path and to interrupt the current. To do this, once a certain time period has passed since initial detection of an excessively high current, the evaluation device 7 uses the Hall sensor 5 to check the current once again and, if the Hall sensor 5 has not

yet been interrupted, activates the load-break switch 19 via the signal line 18. At least for the DC isolation (which is no longer possible by means of the microrelay switch 1) of a current which is otherwise limited by the PTC polymer thermistor 16, the load-break switch can, however, also interrupt the current, provided the switching capacity is adequate. One of the switches, as shown in Figure 2, upstream and downstream of the fuse link 11 can, of course, also be actuated via a signal line 18 in an appropriate manner.

Apart from this, the second exemplary embodiment corresponds to the first, shown in Figure 2.

Figure 5 shows a third exemplary embodiment. In this case, a power breaker 17 is introduced instead of the fuse link 11 from Figure 2 and the PTC thermistor 16 from Figure 4. Apart from this, this exemplary embodiment likewise corresponds to the two exemplary embodiments shown in Figures 2 and 4. If a conventional power breaker 17 is used, then it normally has its own tripping mechanism, for example by means of an inductive drive, which responds to short-circuit currents. However, as an alternative to this, electrical tripping can also be provided by means of a further tripping signal, emitted via a line 18 (see Figure 4), from the evaluation device 7. The line 18 in Figure 5 should thus be regarded as an optional feature. Furthermore, in this case, although it is possible to retain the conventional inductive short-circuit current tripping in the power breaker 17, it is, however, possible to dispense with the bimetallic tripping, which is likewise conventionally provided, in response to relatively small overcurrents. This can then be replaced by tripping initiated by the evaluation device 7 via the line 18.

An exemplary embodiment with a fault-current protection function would differ from the exemplary embodiments

described here only by the evaluation device 7 having corresponding additional functions, and by the Hall sensor 5 detecting the total current through two adjacent current paths, or by providing two Hall sensors.

Figure 6 shows an example of the time response of the microrelay switch 1 and of the PTC polymer thermistor 16 from Figure 4 for the preferred exemplary embodiment of an electric motor switching and protection system. The current axis, annotated I, indicates a motor rated current I_N (in this case 1 A), and a motor starting current amounting to six times the motor rated current I_N . The time axis, annotated t, indicates the physically shortest possible response of the microrelay switch of (as an example) 0.0001 s at its lower end, and the typical time duration of the motor starting current, as 5 s. The dashed line with the reference number 20 shows, schematically, the starting response of the electric motor, which draws the current $6 I_N$ for a period of 5 s, after which the current I_N is drawn. The response characteristic of the microrelay switch 1 and of the evaluation device 7, must be adapted accordingly, as symbolized by the line 21. The circuitry to provide this response is implemented in the evaluation device 7. The line 22 shows a typical response of a PTC polymer thermistor 16, with the response speed increasing for large currents.

In this case, the physically predetermined time delay of 0.0001 s has been increased by means of the evaluation device, in order to shift the intersection of the lowermost horizontal section of the line 21 with the line 22 toward lower current levels, in order thus to reduce the currents to be switched by the microrelay switch 1 for a faster response. In this case, the value of 0.1 s is a typical value for the response of a conventional contactor. Even with this better value of about 0.03 s for a contactor, the value of 0.001 s

chosen for the microrelay switch in this case is thus considerably shorter so that, even if concessions are made with regard to the described reduction in the current that is to be switched quickly, considerable improvements are thus still possible in comparison to the prior art.

Figure 7 shows a diagram analogous to Figure 6, but relating to the exemplary embodiment shown in Figure 5.

10 In this case, the line 23 shows the response of the power breaker 17 which is governed in the upper region by conventional bimetallic overcurrent tripping, and in the lower, horizontally running, region of the curve 23, by the response time of the electromagnetic impact armature, which is largely constant independently of the current. If the response of the microrelay switch 1 is delayed by the evaluation device 7 to such an extent that it results in a comparatively earlier response of the power breaker after about 0.003-0.005 s in response to large currents, these values are still considerably below the conventional values that have been mentioned. One precondition for this is that the microrelay switch 1 can interrupt currents below the tripping threshold of the electromagnetic impact armature, in the example described here below 10 I_N. As can be seen, the use of the microrelay switch 1 according to the invention offers the advantage that response which is at least matched to the response time of the electromagnetic impact armature can be offered in the region of the currents which must otherwise be switched off by means of the bimetallic tripping of the power breaker 17 or by means of an electromagnetic contactor. In principle, in the region of the currents which can be switched off by the microrelay switch 1, it would also be possible to set an even faster response for the microrelay switch 1 than the value predetermined by the response time of the electromagnetic impact armature. However, this would result in the response of the microrelay switch 1 being dependent on the current, with a minimum

response time only for relatively small overcurrents. However, in this exemplary embodiment, a response delay is invariably chosen which is matched to the response of the impact armature, taking into account the increased starting current of the electric motor, in the already described manner.

Claims:

1. An electrical switching device having a microrelay switch (1) in a current path (8), having a short-circuit current limiter (11, 16, 17) in the current path (8) for interrupting a large overcurrent, and having an evaluation device (7) for receiving and evaluating signals from a current sensor (5) which detects the current through the current path (8), with the switching device being designed such that the microrelay switch (1) opens in response to a tripping signal (9) from the evaluation device (7) in the event of small overcurrents above a threshold value and, in the event of large overcurrents, the short-circuit current limiter (11, 16, 17) limits these currents to currents which can be interrupted by the microrelay switch (1).

2. The electrical switching device as claimed in claim 1, in which the evaluation device (7) causes the microrelay switch (1) to respond with a short time delay as a function of the magnitude of any overcurrent.

3. The electrical switching device as claimed in claim 1 or 2, in which the short-circuit current limiter is a fuse link (11).

4. The switching device as claimed in claim 1 or 2, in which the short-circuit current limit (17) can be uploaded electrically, and the evaluation device (7) is designed to transmit a second tripping signal (18) to the short-circuit current limiter (17) in the event of large overcurrents.

5. The electrical switching device as claimed in claim 1, 2 or 3, in which the short-circuit current limiter is a power breaker (17).

5 7. The electrical switching device as claimed in
claim 6, in which the PTC thermistor (16) contains a
PTC polymer material.

8. The electrical switching device as claimed in
10 claim 6, in which the PTC thermistor (16) contains a
PTC metal material.

9. The electrical switching device as claimed in one of the preceding claims, in which the evaluation device
15 (7) is designed for receiving and evaluating signals from a first current sensor (5), which detects the current through the current path (8), and from a second current sensor, which detects a current through a second current path, by comparing them with one another
20 and opening the microrelay switch (1) in response to a result of the evaluation.

10. The electrical switching device as claimed in one of claims 1-8, in which the current sensor (5) is a
25 total current sensor which detects a total current through the current path (8) and through at least one second adjacent current path, and the evaluation device (7) is designed for receiving and evaluating a signal from the total current sensor and for opening the
30 microrelay switch (1) in response to that signal.

11. The electrical switching device as claimed in one of the preceding claims, in which at least one current sensor (5) is part of the switching device and is in the form of a Hall sensor.

12. The electrical switching device as claimed in one of the preceding claims, in which the microrelay switch

(1) has microrelay cells (3) connected in series as a voltage divider.

13. The electrical switching device as claimed in one
5 of the preceding claims, in which the microrelay switch (1) has microrelay cells (3) connected in parallel as a current divider.

14. The electrical switching device as claimed in one
10 of the preceding claims, in which the microrelay switch (1) has at least one microrelay (3) with a contact piece (4) which moves mechanically in an electrostatic manner.

15. The electrical switching device as claimed in one
of the preceding claims, in which the microrelay switch, the evaluation device and, possibly, the Hall sensor or sensors are each integrated as chips on a circuit board.

16. The electrical switching device as claimed in one
of the preceding claims, in which the microrelay switch (1) and the evaluation device (7) are integrated on one chip (6).

17. The electrical switching device as claimed in
claim 11, also in conjunction with any further one of
the preceding claims, in which the evaluation device (7) and the Hall sensor or sensors (5) are integrated
30 on a chip (6).

18. The electrical switching device as claimed in
claim 11, also in conjunction with any further one of
the preceding claims, in which the microrelay switch
35 (1), the evaluation device (7) and the Hall sensor or sensors (5) are integrated on one chip (6).

19. The electrical switching device as claimed in one
of the preceding claims, in which an electronic

response monitoring device (7) is integrated, with the microrelay switch (1), on one chip (6).

20. The electrical switching device as claimed in one
5 of the preceding claims, in which a timer circuit is integrated, with the microrelay switch (1), on one chip (6).

21. An electric motor switching and protection system
10 having an electrical switching device as claimed in one of the preceding claims.

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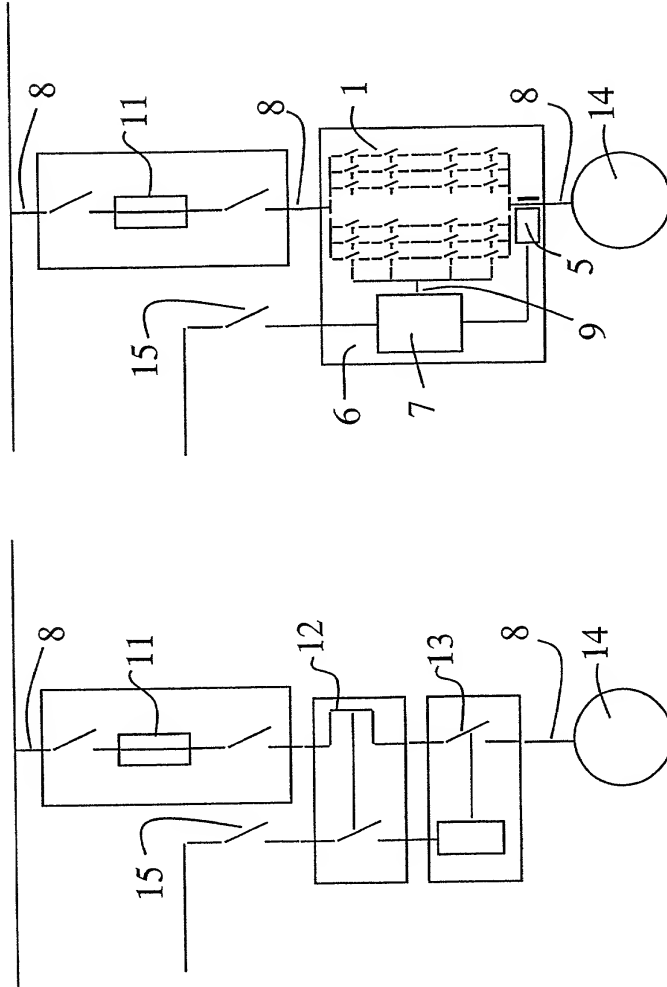


Fig. 2

Fig. 1

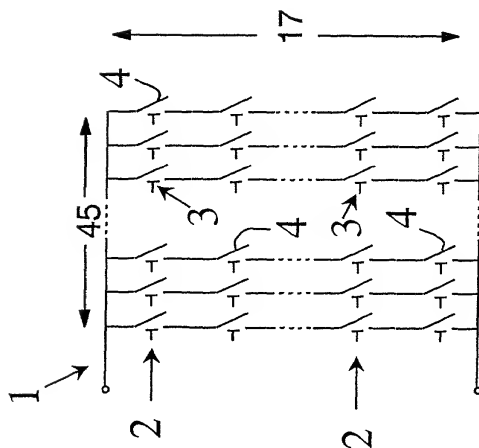


Fig. 3

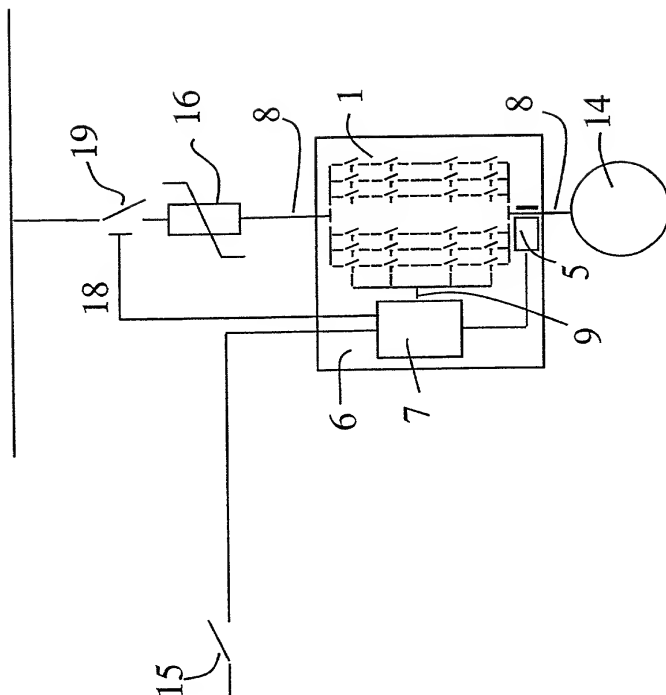


Fig. 4

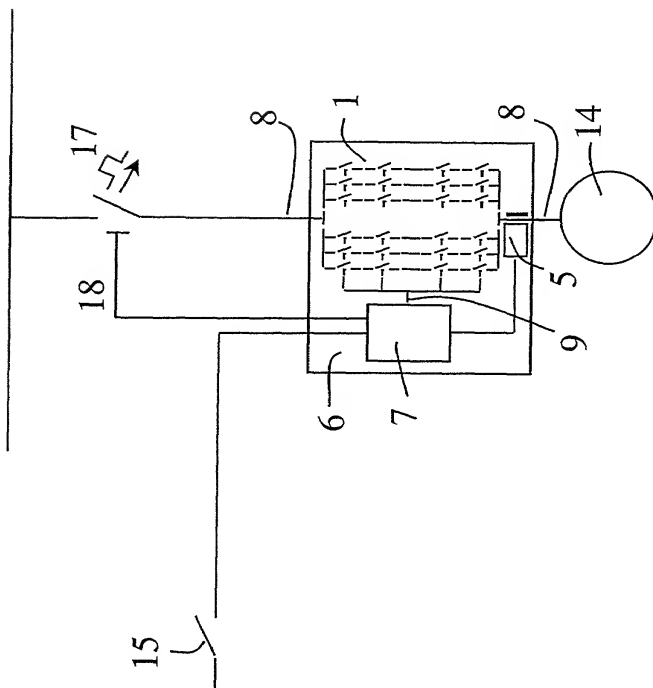


Fig. 5

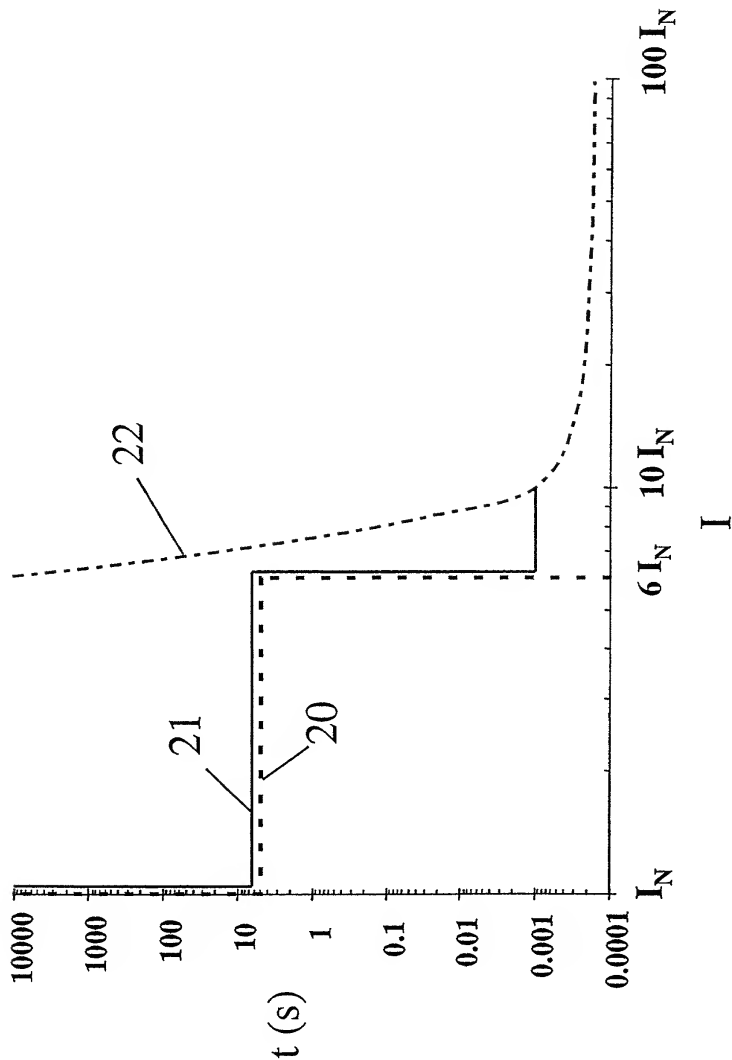


Fig. 6

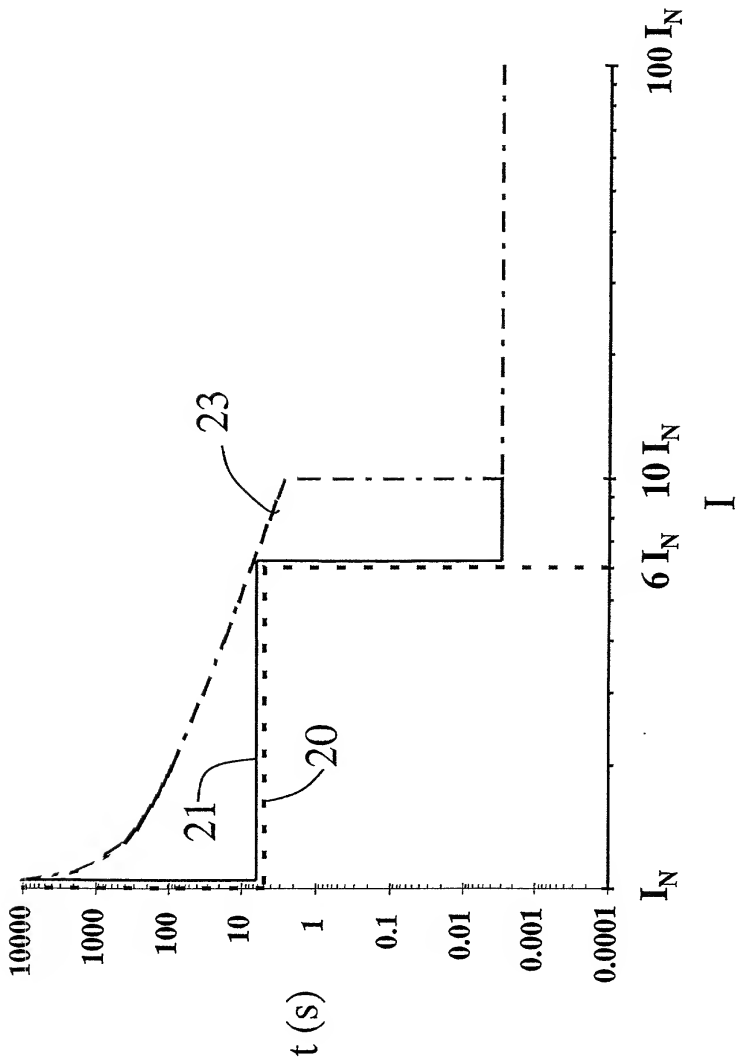


Fig. 7

COMBINED DECLARATION FOR PATENT APPLICATION AND POWER OF ATTORNEY
(Includes Reference to Provisional and International (PCT) Applications)

Attorney's Docket No.

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name;

I BELIEVE I AM THE ORIGINAL, FIRST AND SOLE INVENTOR (IF ONLY ONE NAME IS LISTED BELOW) OR AN ORIGINAL, FIRST AND JOINT INVENTOR (IF PLURAL NAMES ARE LISTED BELOW) OF THE SUBJECT MATTER WHICH IS CLAIMED AND FOR WHICH A PATENT IS SOUGHT ON THE INVENTION ENTITLED:

Electrical switching device for overcurrent protection

The specification of which (check only one item below):

- ☐ is attached hereto.
- ☐ was filed as United States Patent Application Number _____
on _____
and was amended on _____ (if applicable).
- ☒ was filed as International (PCT) Application Number PCT/CH00/00325
on 2000-06-14
and was amended on _____ (if applicable).

I HAVE REVIEWED AND UNDERSTAND THE CONTENTS OF THE ABOVE-IDENTIFIED SPECIFICATION, INCLUDING THE CLAIMS, AS AMENDED BY ANY AMENDMENT REFERRED TO ABOVE.

I ACKNOWLEDGE THE DUTY TO DISCLOSE TO THE U.S. PATENT AND TRADEMARK OFFICE ALL INFORMATION KNOWN TO ME TO BE MATERIAL TO PATENTABILITY AS DEFINED IN TITLE 37, CODE OF FEDERAL REGULATIONS, Sec. 1.56 (as amended effective March 16, 1992);

I do not know and do not believe the said invention was ever known or used in the United States of America before my or our invention thereof, or patented or described in any printed publication in any country before my or our invention thereof or more than one year prior to said application; that said invention was not in public use or on sale in the United States of America more than one year prior to said application; that said invention has not been patented or made the subject of an inventor's certificate issued before the date of said application in any country foreign to the United States of America on any application filed by me or my legal representatives or assigns more than six months prior to said application;

I hereby claim foreign priority benefits under Title 35, United States Code, §§ 119 (a)-(e) of any foreign application(s) for patent or inventor's certificate or of any International (PCT) Application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT International (PCT) Application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed:

PRIOR FOREIGN/PCT APPLICATION(S) AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. §119:

| COUNTRY (If PCT, indicate "PCT") | APPLICATION NUMBER | DATE OF FILING (day, month, year) | PRIORITY CLAIMED UNDER 35 U.S.C. §119 |
|-------------------------------------|--------------------|--------------------------------------|---|
| Germany | 199 27 762.1 | 17.06.1999 | <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No |
| | | | <input type="checkbox"/> Yes <input type="checkbox"/> No |
| | | | <input type="checkbox"/> Yes <input type="checkbox"/> No |
| | | | <input type="checkbox"/> Yes <input type="checkbox"/> No |
| | | | <input type="checkbox"/> Yes <input type="checkbox"/> No |

I hereby claim the benefit under Title 35, United States Code § 119(e) of any United States provisional application(s) listed below.

(APPLICATION NUMBER)

(FILING DATE)

(APPLICATION NUMBER)

(FILING DATE)

COMBINED DECLARATION FOR PATENT APPLICATION AND POWER OF ATTORNEY (CONT'D)
(Includes Reference to Provisional and International (PCT) Applications)Attorney's Docket
No.

I hereby claim the benefit under Title 35, United States Code, § 120 of any United States application(s) or International (PCT) Application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose to the U.S. Patent and Trademark Office all information known to me to be material to the patentability as defined in Title 37, Code of Federal Regulations § 1.56, which became available between the filing date of the prior application(s) and the national or international filing date of this application:

PRIOR U.S. APPLICATIONS OR INTERNATIONAL (PCT) APPLICATIONS DESIGNATING THE U.S. FOR BENEFIT UNDER 35 U.S.C. § 120:

| U.S. APPLICATIONS | | STATUS (check one) | | |
|---------------------------------------|------------------|--|--------------------------|--------------------------|
| U.S. APPLICATION NUMBER | U.S. FILING DATE | PATENTED | PENDING | ABANDONED |
| | | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| | | | | |
| | | | | |
| PCT APPLICATIONS DESIGNATING THE U.S. | | | | |
| PCT APPLICATION NO. | PCT FILING DATE | U.S. APPLICATION NUMBERS ASSIGNED (if any) | | |
| PCT/CH00/325 | 2000-06-14 | | | |
| | | | | |
| | | | | |

I hereby appoint the following attorneys and agent(s) to prosecute said application and to transact all business in the U.S. Patent and Trademark Office connected therewith and to file, prosecute and to transact all business in connection with international applications directed to said invention:

| | | | | | |
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| Ronald L. Grudziecki | 24,970 | T. Gene Dillahunty | 25,423 | Brian P. O'Shaughnessy | 32,747 |
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| Alan E. Kopecki | 25,813 | B. Jefferson Boggs, Jr. | 32,344 | Fred W. Hathaway | 32,236 |
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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

**COMBINED DECLARATION FOR PATENT APPLICATION AND POWER OF ATTORNEY
(CONT'D)**
(Includes Reference to Provisional and International (PCT) Applications)

Attorney's Docket No.

| | | | |
|--|--|------------------------------------|--------------------|
| FULL NAME OF SOLE OR FIRST INVENTOR Ralf Strümpfer | | SIGNATURE <i>Ralf Strümpfer</i> | DATE 2001-11-22 |
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| RESIDENCE (CITY & STATE/COUNTRY) | | CITIZENSHIP | |
| POST OFFICE ADDRESS (HOME ADDRESS) | | | |
| FULL NAME OF THIRD JOINT INVENTOR, IF ANY | | SIGNATURE | DATE |
| RESIDENCE (CITY & STATE/COUNTRY) | | CITIZENSHIP | |
| POST OFFICE ADDRESS (HOME ADDRESS) | | | |
| FULL NAME OF FOURTH JOINT INVENTOR, IF ANY | | SIGNATURE | DATE |
| RESIDENCE (CITY & STATE/COUNTRY) | | CITIZENSHIP | |
| POST OFFICE ADDRESS (HOME ADDRESS) | | | |
| FULL NAME OF FIFTH JOINT INVENTOR, IF ANY | | SIGNATURE | DATE |
| RESIDENCE (CITY & STATE/COUNTRY) | | CITIZENSHIP | |
| POST OFFICE ADDRESS (HOME ADDRESS) | | | |
| FULL NAME OF SIXTH JOINT INVENTOR, IF ANY | | SIGNATURE | DATE |
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| FULL NAME OF SEVENTH JOINT INVENTOR, IF ANY | | SIGNATURE | DATE |
| RESIDENCE (CITY & STATE/COUNTRY) | | CITIZENSHIP | |
| POST OFFICE ADDRESS (HOME ADDRESS) | | | |
| FULL NAME OF EIGHTH JOINT INVENTOR, IF ANY | | SIGNATURE | DATE |
| RESIDENCE (CITY & STATE/COUNTRY) | | CITIZENSHIP | |
| POST OFFICE ADDRESS (HOME ADDRESS) | | | |
| FULL NAME OF NINTH JOINT INVENTOR, IF ANY | | SIGNATURE | DATE |
| RESIDENCE (CITY & STATE/COUNTRY) | | CITIZENSHIP | |
| POST OFFICE ADDRESS (HOME ADDRESS) | | | |
| FULL NAME OF TENTH JOINT INVENTOR, IF ANY | | SIGNATURE | DATE |
| RESIDENCE (CITY & STATE/COUNTRY) | | CITIZENSHIP | |
| POST OFFICE ADDRESS (HOME ADDRESS) | | | |